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A method and a device for the liquefaction of natural gas

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COMPLETE SPECIFICATION

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INVENTION TITLE:

A method and a device for the liquefaction of natural gas

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

Abstract

A method and a device for the liquefaction of natural gas are described. For a reliable operation of the compressors existing in natural gas liquefaction plants it is proposed to obtain the energy for driving the compressors from the combustion of a portion of the liquefied natural gas (D1). Gas turbines can, in particular, be operated with vaporised (E1,E2) liquid natural gas as the fuel gas. In this way, fuel gas with a homogeneous composition and constant heating value is made available which is also suitable for use in modern gas turbines which react sensitively to fluctuations in the composition and the heating value of the fuel gas.

(Fig. 1)

Description

The invention relates to a method for the liquefaction of natural gas by using at least one refrigerant cycle stream, which is compressed by means of at least one compressor, as well as a device for executing the method.

Natural gas is liquefied in so-called LNG base load plants, i.e. plants for the base load supply with liquefied natural gas (LNG), in order to supply, at other locations, the energy market with natural gas as the primary energy. As a rule, such plants have several refrigerant cycles with compressors to compress the refrigerant cycle streams. Large amounts of energy are required for the compression of refrigerant cycle streams. Usually, the compressors are driven by means of gas turbines which are supplied with fuel. The energy generated in the gas turbines during the combustion of the fuel is transferred either direct to the compressor drive shafts or is used for the power generation by means of generators in order to drive, with the power thus generated, electric drive motors which drive the compressors. To supply the gas turbines with fuel, residual gases or gases from the liquefaction process, for instance from the nitrogen removal, or also raw gas are used. These fuel gases are compressed in fuel gas compressors to the necessary fuel gas pressures of between approx. 20 to approx. 30 bar. In order to keep the energy consumption for the compression of the refrigerant cycle streams as low as possible, attempts are made to use the latest available gas turbines offering the greatest efficiencies. These so-called air-derivative gas turbines require for their operation fuel gases with slightly higher pressures than conventional gas turbines. Furthermore, they are sensitive to small short-term and medium-term changes in the composition of the fuel gases or fluctuations in the heating value of the fuel gases. For instance even fluctuations in the heating value or the specific gravity or the Wobbe index of the fuel gas of +/– 1 % within 30 seconds are critical for the operation of highly efficient gas turbines. This means that a continuous operation of these gas turbines with the fuel gases used up to date cannot be ensured, because in view of a possible gas turbine failure the availability of the natural gas liquefaction process as a whole cannot be guaranteed. The reduced availability of the natural gas liquefaction process resulting

therefrom would lead to a reduction of the annually produced quantity of liquefied natural gas.

It is the object of the present invention to provide a method of the type mentioned at the outset, as well as a device for the execution of the method, by means of which a reliable and economical operation of the compressors is rendered possible.

The object of the invention with regard to the method is achieved in that the compressor is driven by energy from the combustion of a portion of the liquefied natural gas.

The drive energy for the operation of the compressors is thus provided by the combustion of liquefied natural gas (LNG). Liquefied natural gas is available at all times, since already for starting up the natural gas liquefaction plant, liquefied natural gas is filled into storage tanks and, during the operation of the liquefaction plant, liquefied natural gas is continuously produced and introduced into tanks. Based on the specification which is set for the operation of the natural gas liquefaction plant, the liquefied natural gas has a very constant composition and a constant heating value. Thus also highly efficient gas turbines of the latest generation, which react critically to fluctuations in the composition or the heating value of the fuel gas, can be operated with the liquefied natural gas.

On principle, any conceivable fuel-operated drive units can be used for driving the compressors. Appropriately, gas turbines with high levels of efficiency, in particular those of the latest generation, are used. In practical applications, the fuel gas produced from the liquefied natural gas by vaporisation of a portion of ... [1][the natural gas] is supplied to at least one gas turbine for combustion, which mechanically drives at least one compressor. The gas turbine can however also be employed to drive a generator for power generation, where with the power thus generated at least one electric motor is operated which drives at least one compressor. Appropriately one portion of the liquefied natural gas is withdrawn from the storage tank for liquefied natural gas by means of a pump and supplied to the gas turbine. For reaching the necessary fuel gas pressure one pump inside or outside the storage tank is sufficient, but, if appropriate, a

further pump can be employed outside the storage tank. This means that by using liquefied natural gas, the required fuel gas pressure for the gas turbines can be achieved with relatively little energy expenditure and low investment costs. An expensive and energy-intensive compression of fuel gas in special fuel gas compressors, as is required in prior art systems, can be dispensed with.

Appropriately, the portion of the liquefied natural gas intended to be used as fuel gas, is converted into the gaseous state by heating. The heating up of the liquefied natural gas is preferably performed by heat exchange with streams which are in any case available in the natural gas liquefaction process. Advantageously, the liquefied natural gas is subjected to heat exchange with a split stream of a top product of a column separating heavy hydrocarbons from the natural gas. In addition or alternatively, the liquefied natural gas can be heated up by heat exchange with a subcooling cycle available in the natural gas liquefaction process. In accordance with a particularly preferred embodiment, the liquid compressed natural gas is vaporised in one or in two successive heat exchangers by heat exchange with a split stream of the top product of the column separating heavy hydrocarbons from a reclaiming tank, which split stream amounts to approx. 5 % to 10 % of the raw gas, and against a split stream of the subcooling cycle (SC) which amounts to approx. 5 % to 10 % of the subcooling cycle stream.

A further variant of the invention proposes to subject to heat exchange a portion of the liquefied natural gas intended for the production of fuel gas with a split stream of the raw gas to be liquefied. Furthermore, the liquefied natural gas can also be heated up by an external heating medium, in particular hot steam or hot oil, or by means of an electric heating system.

In an embodiment of the invention which is particularly well suited to practical applications, a portion of the liquefied natural gas is pumped out of a storage tank for liquefied natural gas, subsequently heated up and vaporised at approx. 30 to 50 bar into fuel gas and finally the fuel gas is supplied to the gas turbine for combustion.

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[1] Translator's note: some words seem to be missing in this sentence

The invention is further directed to a device for the liquefaction of natural gas having at least one refrigerant cycle and at least one compressor to compress the refrigerant cycle stream, where the compressor interacts with at least one fuel-operated drive unit.

The object of the invention in as far as the device is concerned is achieved in that the drive unit is connected via a fuel supply line with a storage container for liquefied natural gas.

Appropriately the drive unit is a gas turbine. Furthermore, at least one heat exchanger for heating up the liquefied natural gas is incorporated into the fuel supply line. The heat exchanger is preferably connected with a top product discharge duct of a column for separating heavy hydrocarbons from the natural gas. In addition or alternatively, the heat exchanger can also be connected with a subcooling cycle of the natural gas liquefaction plant. The heat exchanger can also be connected with a raw gas split stream line which branches off from the supply line to the natural gas liquefaction plant.

The invention offers a number of advantages.

For the operation of highly efficient gas turbines according to the latest state of the art, the so-called air-derivative gas turbines, a fuel gas is made available which is stable with regard to its composition and heating value. Thus, the probability of a failure of the gas turbines due to variations in the quality of the fuel gas is reduced to a minimum. Through the vaporisation of the liquefied natural gas by heat exchange with a raw gas split stream or a cycle split stream, the available coldness of the liquefied natural gas is practically fully recovered. The high energy expenditure involved in the compression of the fuel gas in the gaseous state in prior art plants is therefore dispensed with. The investment costs of the hydraulic pumps for the compression to fuel gas pressure are lower than the investment costs incurred for the fuel gas compressors in the prior art plants. With the heat exchangers proposed, the temperature of the fuel gas can be set whilst observing the required distance from the dew point. On the whole, the most important aim in the achievement of the object of the invention, namely to provide a fuel gas for the gas turbine operation which is conditioned with regard to its composition and heating value and is temporally stable, is accomplished in a technically

elegant and economical manner. Therefore, the disadvantage of a lower liquefaction capacity of the natural gas liquefaction plant using conventional gas turbines with lower efficiency levels is avoided.

The invention is described in greater detail below by reference to embodiment examples schematically presented in the figures.

Shown are in

Figure 1	a flow chart for a method for conditioning fuel gas for gas turbines in a natural gas liquefaction plant
Figures 2 and 3	variations of the method shown in Figure 1 with different heat exchanger embodiments.

From the storage tank D1 for liquefied natural gas shown in Figure 1, the fuel gas volume required for the operation of the gas turbines is pumped out in the form of liquefied natural gas by means of pump P1. The compression to the required fuel gas pressure can be executed fully by means of pump P1 positioned inside the storage tank D1 or by pump P2 arranged outside, or also in two steps. This means that the compression can also be executed by means of a pump P1 positioned in the storage tank D1 and with a second pump P2 outside of the storage tank D1, in order to minimise for instance the heat input and therefore the so-called boil-off-gas volume of the storage tank D1. In a heat exchanger E1, the liquefied natural gas is gasified to between 30 and 50 bar in heat exchange with a split stream of the gas stream from the reclaiming tank D2 of the HHC column T1 (column for the separation of heavy hydrocarbons). In a further heat exchanger E2 the cold fuel gas stream is heated up by heat exchange with a split stream of the subcooling cycle (SC) to ambient temperature and the required superheating to reach the dew point temperature is adjusted. The split stream of the top product of the HHC column T1 cooled by the pumped, liquefied gas, which is being heated up, is liquefied at the outlet of the heat exchanger E1 and sufficiently subcooled, so that it can again be mixed with the main stream of the liquefied, subcooled natural

gas of the process. The mixed, subcooled natural gas stream can then be fed into the storage tank D1 via a liquid expansion turbine X1 or a Joule-Thomson Valve V1. This means that also the split top product stream is used for the refrigerating process.

The split stream of the subcooling cycle (SC), also used for heating, is discharged from the heat exchanger E2 in two phases and is again mixed with the two-phase main stream of the subcooling cycle. Due to the stable temperature conditions and prevailing process pressures, the heat exchangers E1 and E2 can be designed as aluminium plate heat exchangers. Also the use of wound heat exchangers or welded stainless steel plate heat exchangers is advantageous. In a further variant type, the heat exchangers E1 and E2 can also be combined to one heat exchanger, in which case this heat exchanger can be designed as an aluminium plate heat exchanger or a wound heat exchanger.

The heating up of the fuel gas stream in the heat exchanger E2, in an alternative to heating by heat exchange with a split stream of the subcooling cycle, can also be executed by heat exchange with the following split streams:

- a split stream of the dry natural gas stream entering into the liquefaction part of the plant or

- a split stream of a further refrigerant cycle entering the plant, for instance by heat exchange with a split stream of the liquefaction cycle (LC) or the precooling cycle (PC).

In the variant shown in Figure 2, the liquefied natural gas pumped and pressurised to fuel gas pressure is heated up in the heat exchangers E1 and E3 or exclusively in heat exchanger E3. In this case, the heat exchanger E3 is designed as follows. The heat exchanger contains two tube nests, with one tube nest being heated by high pressure steam or hot oil. The liquid natural gas or the now gaseous natural gas vaporised in heat exchanger E1 are contained in the second tube nest. Both tube nests are positioned in a closed container, which is filled with a transfer medium for the purpose of heat transfer between the two tube nests. As the heat transfer medium, a medium is selected which vaporises or condenses in the temperature range between the heating medium, namely

steam or hot oil of approx. 100°C to approx. 250°C, and the vaporising or heating up liquid natural gas of approx. -160 °C to -50°C, under medium pressures of about 10-25 bar. Furthermore the medium should have good heat transfer properties and the melting point should be below approx. -160°C. The following media may be taken into consideration: ethane, propane, propylene. In the present example, propane was selected. For propane a boiling pressure of 12 bar was selected, which corresponds to a boiling temperature of 34°C. The arrangement presented in Figure 2 for the vaporisation or heating up of the liquid natural gas in the heat exchanger E3 is an option which can be used in one phase of the starting period until the corresponding refrigerant cycles have been set into operation. In this option the liquefied natural gas pumped from the storage tank D1 is conveyed, via a bypass around the heat exchanger E1, direct to the heat exchanger E3 and is there vaporised and heated up.

Figure 3 shows a variation of the method where, instead of the liquid natural gas pumped and pressurised to fuel gas pressure being heated up in the heat exchangers E1 and E2, the heating up is performed in the heat exchanger E4. The heat exchanger E4 is designed as an electric heater. The electric heater is either dimensioned for continuous operation or only for the starting operation. This arrangement is a further option which can be used during the starting period, i.e. until the corresponding refrigerant cycles have been set into operation.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgement or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for the liquefaction of natural gas by means of at least one refrigerant cycle, which is compressed by means of at least one compressor, characterised in that said compressor is driven by energy generated by the combustion of a portion of said liquefied natural gas.

2. A method according to Claim 1, characterised in that fuel gas produced by vaporisation of a portion of said liquefied natural gas is supplied to at least one gas turbine which mechanically drives at least one compressor.

3. A method according to Claim 1, characterised in that fuel gas produced by vaporisation of a portion of said liquefied natural gas is supplied to at least one gas turbine for combustion, which drives at least one generator for the generation of power, wherein by the power thus generated at least one electric motor is operated which drives at least one compressor.

4. A method according to one of Claims 1 to 3, characterised in that said portion of said liquefied natural gas is heated up.

5. A method according to Claim 4, characterised in that said heating up of said liquefied natural gas is executed by heat exchange with a cycle stream available in the natural gas liquefaction process.

6. A method according to Claim 4 or 5, characterised in that said heating up of said liquefied natural gas is executed by heat exchange with a split stream of a top product of a column for separating heavy hydrocarbons from said natural gas.

7. A method according to one of Claims 4 to 6, characterised in that said heating up of said liquefied natural gas is executed by heat exchange with a part stream of a subcooling cycle available in the natural gas liquefaction process.

8. A method according to one of Claims 4 to 7, characterised in that said heating up of said liquefied natural gas is executed by heat exchange with a split stream of the raw gas to be liquefied.

9. A method according to one of Claims 4 to 8, characterised in that said heating up of said liquefied natural gas is executed by heating up with an external heating medium, in particular hot steam or hot oil.

10. A method according to one of Claims 4 to 9, characterised in that said heating up of said natural gas is executed by means of an electric heater.

11. A method according to one of Claims 2 to 10, characterised in that, from a storage tank for liquefied natural gas, a portion of said liquefied natural gas is pumped out, subsequently heated up and at approx. 30 to approx. 50 bar is vaporised to form fuel gas and that finally said fuel gas is supplied to said gas turbine for combustion.

12. A device for the liquefaction of natural gas by means of at least one refrigerant cycle and at least one compressor for the compression of said refrigerant cycle, where the compressor interacts with at least one fuel-operated drive unit, characterised in that said drive unit is connected via a fuel supply line with a storage container for liquefied natural gas.

13. A device according to Claim 12, characterised in that said drive unit is in the form of a gas turbine.

14. A device according to Claim 12 or 13, characterised in that at least one heat exchanger for heating up said liquefied natural gas is incorporated into said fuel supply line.

15. A device according to Claim 14, characterised in that said heat exchanger is connected with a top product discharge duct of a column for separating heavy hydrocarbons from said natural gas.

16. A device according to Claim 14 or 15, characterised in that said heat exchanger is connected with a subcooling cycle, liquefaction cycle or precooling cycle of said natural gas liquefaction plant.

17. A device according to one of Claims 14 to 16, characterised in that said heat exchanger is connected with a raw gas split stream line.

18. A device according to one of Claims 14 to 17, characterised in that said heat exchanger is equipped with an external heater which can be operated with hot oil or hot steam.

19. Method and/or apparatus for the liquefaction of natural gas substantially as hereinbefore described with reference to the drawings.

20. The steps, features, compositions and compounds disclosed herein or referred to or indicated in the specification and/or claims of this application, individually or collectively, and any and all combinations of any two or more of said steps or features.

DATED this TWENTY THIRD day of APRIL 2002

Linde Aktiengesellschaft AND Den norske stats oljeselskap a.s.

by DAVIES COLLISON CAVE
Patent Attorneys for the applicant(s)

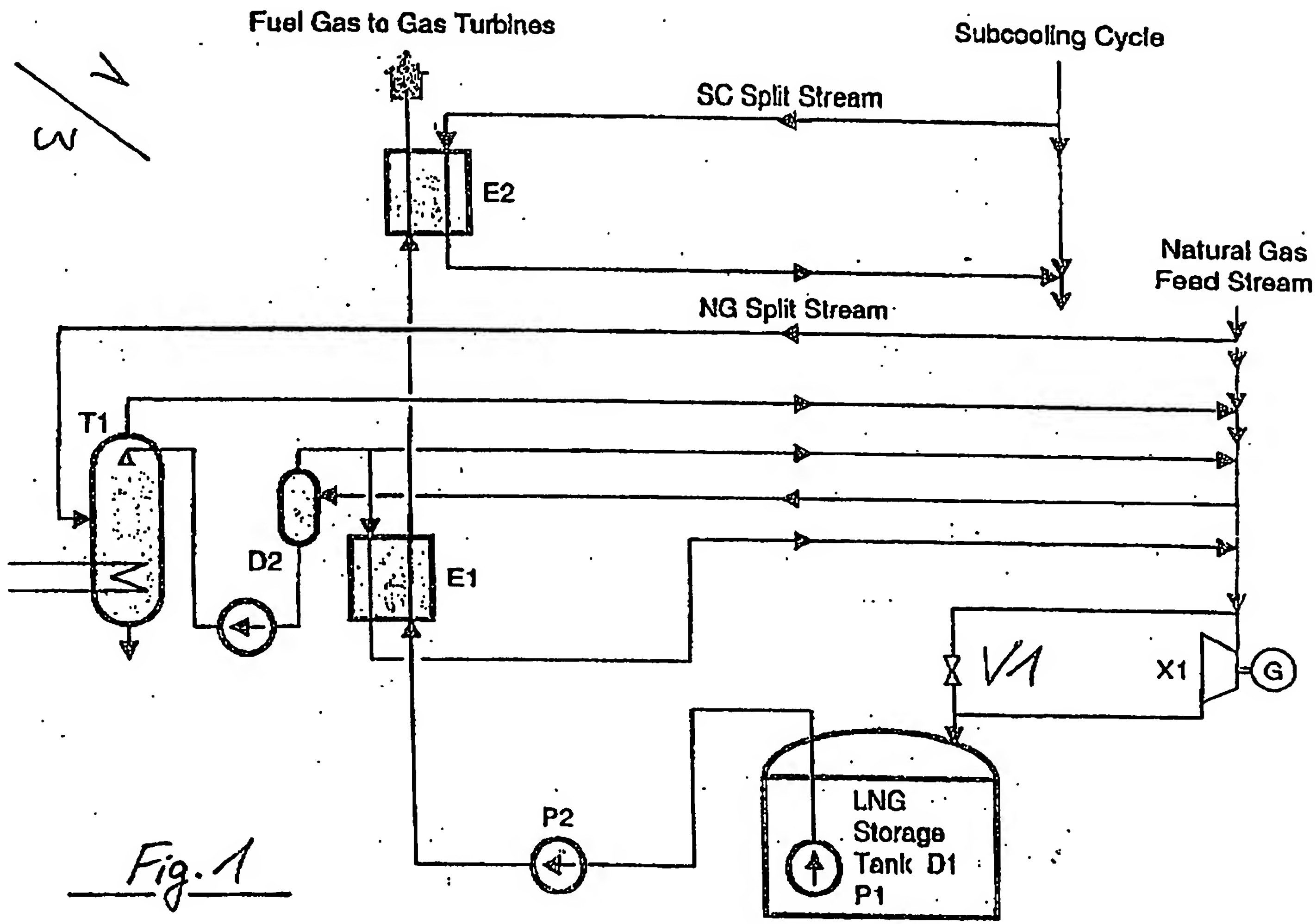
Fuel Gas to Gas Turbines
Subcooling Cycle
SC Split Stream
E2
Natural Gas
Feed Stream
NG Split Stream
T1
D2
E1
V1
X1
G
P2
LNG
Storage
Tank D1
P1

Fig. 1

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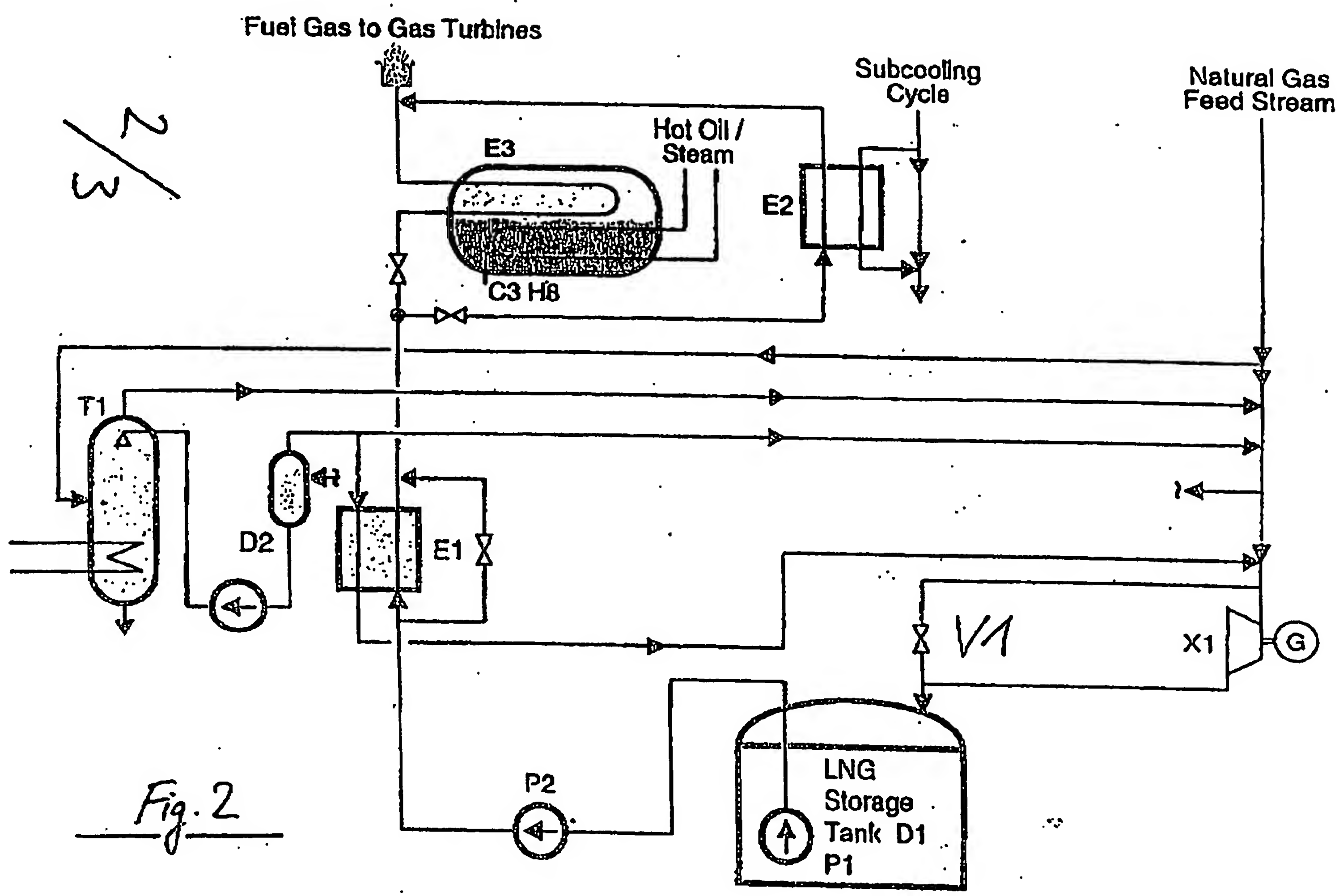
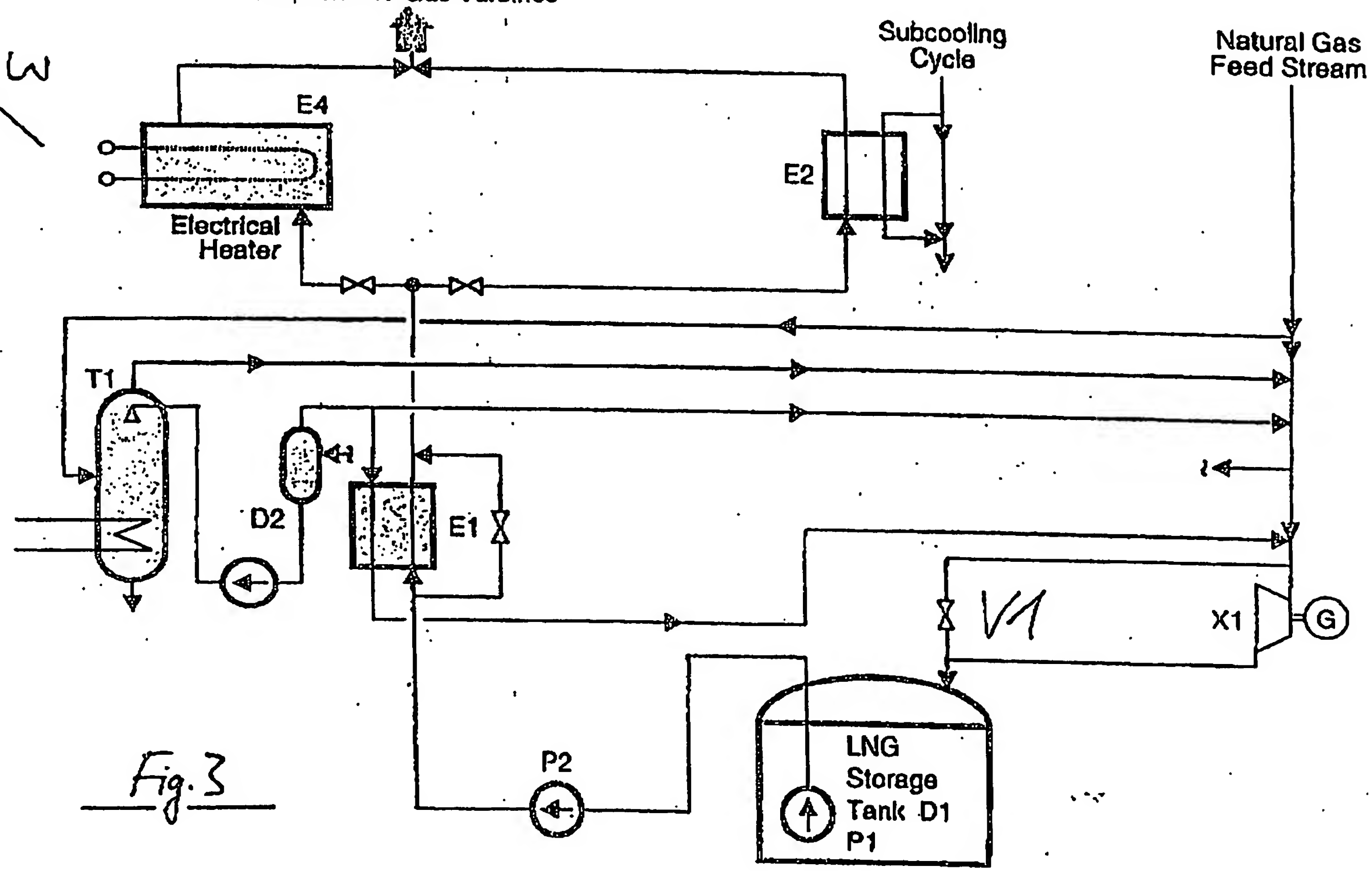


Fuel Gas to Gas Turbines
Subcooling Cycle
Natural Gas Feed Stream
E3
Hot Oil / Steam
E2
C3 H8
T1
D2
E1
V1
X1
G
P2
LNG Storage Tank D1
P1

Fig. 2

3/3



Fuel Gas to Gas Turbines
Subcooling Cycle
Natural Gas Feed Stream
E4
Electrical Heater
E2
T1
D2
E1
V1
X1
G
P2
LNG Storage Tank D1
P1

Fig. 3